भारतीय मानक
Indian Standard

IS 17429 : 2020

सोलर फोटोवोल्टेक वॉटर पम्पिंग सिस्टम — परीक्षण प्रक्रियाओं हेतु — दिशा निर्देश

Solar Photovoltaic Water Pumping Systems — Testing Procedure — Guidelines

ICS 27.160

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भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुरशाह ज़फर मार्ग, नई दिल्ली – 110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI-110002
www.bis.gov.in   www.standardsbis.in

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Pumps Sectional Committee, MED 20

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Pumps Sectional Committee had been approved by the Mechanical Engineering Divisional Council.

This standard is primarily intended to introduce testing set up and testing procedures for Solar Photovoltaic (SPV) water pumping system, testing requirements for solar photo voltaic water pumping systems and prescribes the method of measurement of performance and energy efficiency rating and testing for performance.

The manufacturers of solar powered water pump set offer an array of equipment to meet the diverse applications of markets. The complexity of the product offering precludes the testing of each and every model. However, to promote consistency in the representation of solar powered water pump set performance by all manufacturers; this standard establishes uniform rating and testing methods. It is intended that equipment testing shallbe done in laboratory where the instrumentation and load stability as defined in the standard can be provided.

The composition of the Committee responsible for the formulation of this standard is given in Annex C.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value shall be the same as that of the specified value in this standard.

Indian Standard

SOLAR PHOTOVOLTAIC WATER PUMPING SYSTEMS — TESTING PROCEDURE — GUIDELINES

1 SCOPE

These guidelines lays down basis for testing set up and testing procedures for Solar Photovoltaic (SPV) water pumping system. The SPV water pumping system covered are centrifugal pumps of all types from 0.75 kW/1 HP up to 7.5 kW/10 HP capacity.

REFERENCES

The Indian standards listed in Annex A contain provisions which, through reference in this text, constitute provision of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated in Annex A.

3 DEFINITION OF SYSTEMS AND PARAMETERS

3.1 Systems

3.1.1 *Stand-Alone Solar PV Water Pumping System*

A solar PV water pumping system in stand-alone operation is neither connected to the grid nor to battery bank and is comprised mainly of the following components and equipment:

PV Modules, cabling, controller, motor pump-set. Combination of all these components shall be unique. Any change in combination shall be treated as different model of pumping system.

3.1.2 *Motor-Pumpset*

The motor-pump set consists of the pump (centrifugal pump) and the driving motor.

3.1.3 *Controller*

The controller converts the d.c. power (d.c. voltage and current) of the PV array into a high or low d.c. voltage power, or converts this d.c. power into single-phase or multi-phase alternating-current power (voltage or alternating current) suitably for driving the motor of Motor-pumpset.

NOTE — The controller may also include equipment for MPPT, monitoring, metering and for Protection purposes.

3.2 Parameters

Following parameter shall be referred during testing of SPV pumping system:

Table 1 Parameters

(*Clause* 3.2)

Sl No. (1)	Parameter (2)	Symbol (3)	Unit (4)
i)	Array voltage (d.c.)	V_a	V
ii)	Array current (d.c.)	I_a	A
iii)	Array open circuit voltage (d.c.)	V_{oc}	V
iv)	Array short circuit current (d.c.)	I_{sc}	A
v)	Array maximum power point voltage (d.c.)	V_{mpp}	V
vi)	Array maximum power point current (d.c.)	I_{mpp}	A
vii)	Pressure as measured	p	kg/cm^2
viii)	Flow rate	Q	lps/lpm /m^3h
ix)	Motor voltage d.c or a.c.	V_m	V
x)	Motor current d.c. or a.c.	I_m	A
xi)	Motor voltage (multi-phase a.c.)	V_{rms}	V
xii)	Motor current (multi-phase a.c)	Irms	A
xiii)	Power factor	cos θ	-
xiv)	a.c frequency (or d.c. switching frequency)	F	Hz
xv)	Motor speed	N	min –1
xvi)	Radiation	E_e	W/m^2
xvii)	Temperature	T	ºC

4 TEST SETUP

4.1 Test Setup

Illustration(s) of test set-ups are shown in Fig. 1 and Fig. 2, and a block diagram of required test set-up is shown in Fig. 3. All test set-ups shall conform to applicable model test set-ups referred above and the water level in the sump well, locations of throttle valve, flow meter and pressure gauge/sensor connections as indicated in the test set-up(s) shall conform to Fig. 1, Fig. 2 and Fig. 3, accordingly.

4.2 Precautions for Test Setup

Before initiating testing of SPV pump the following precautions shall be followed:

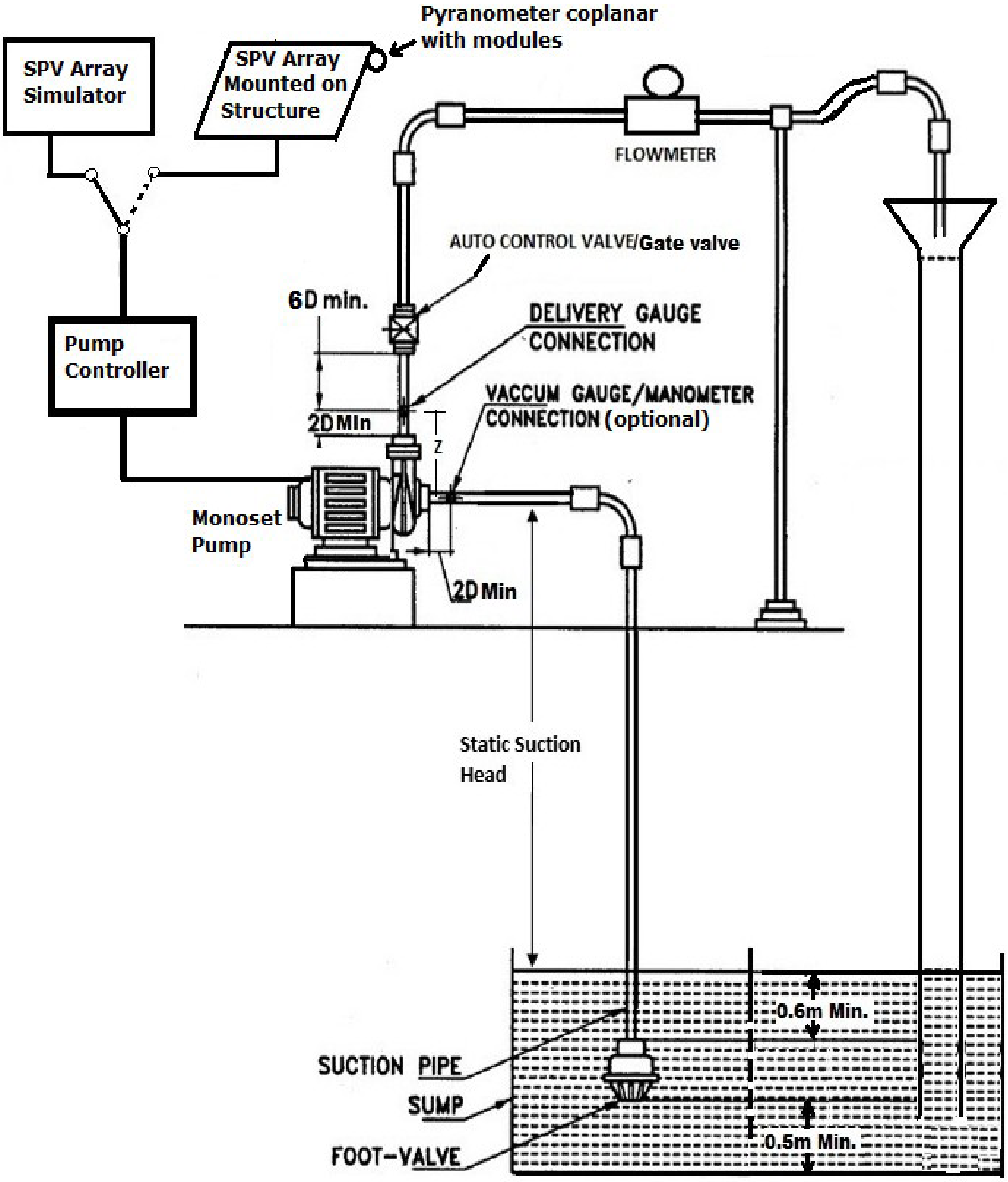

Pyranometer coplanar with modules
SPV Array Simulator
SPV Array Mounted on Structure
FLOWMETER
AUTO CONTROL VALVE/Gate valve
6D min.
DELIVERY GAUGE CONNECTION
Pump Controller
VACCUM GAUGE/MANOMETER CONNECTION (optional)
2D Min
Z
Monoset Pump
2D Min
Static Suction Head
0.6m Min.
SUCTION PIPE
SUMP
FOOT-VALVE
0.5m Min.

FIG. 1 TYPICAL TEST SET-UP FOR SUBMERSIBLE SPV WATER PUMP-SET

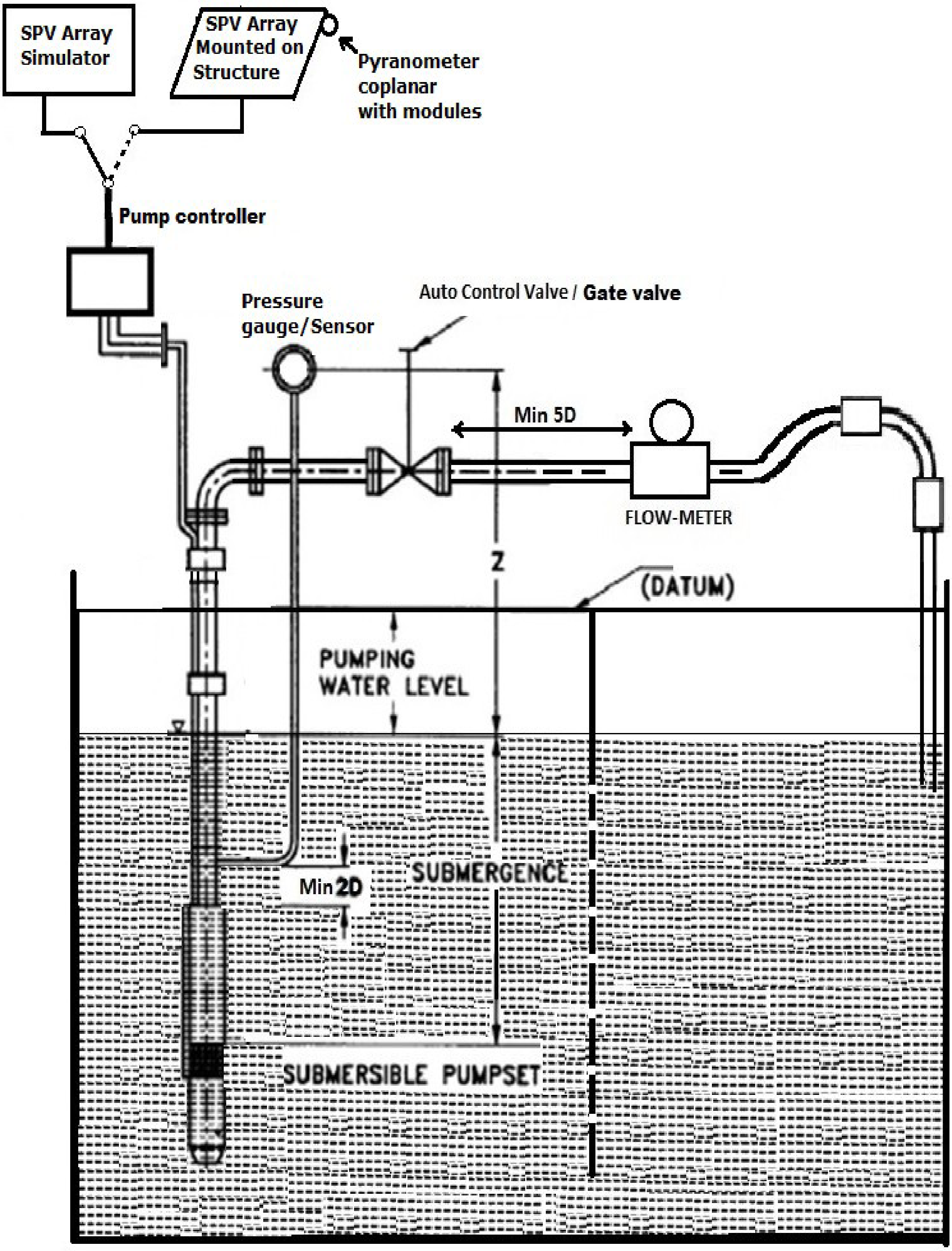


FIG. 2 – Typical Test Set-up for SPV Surface/Mono-Set Water Pump Set

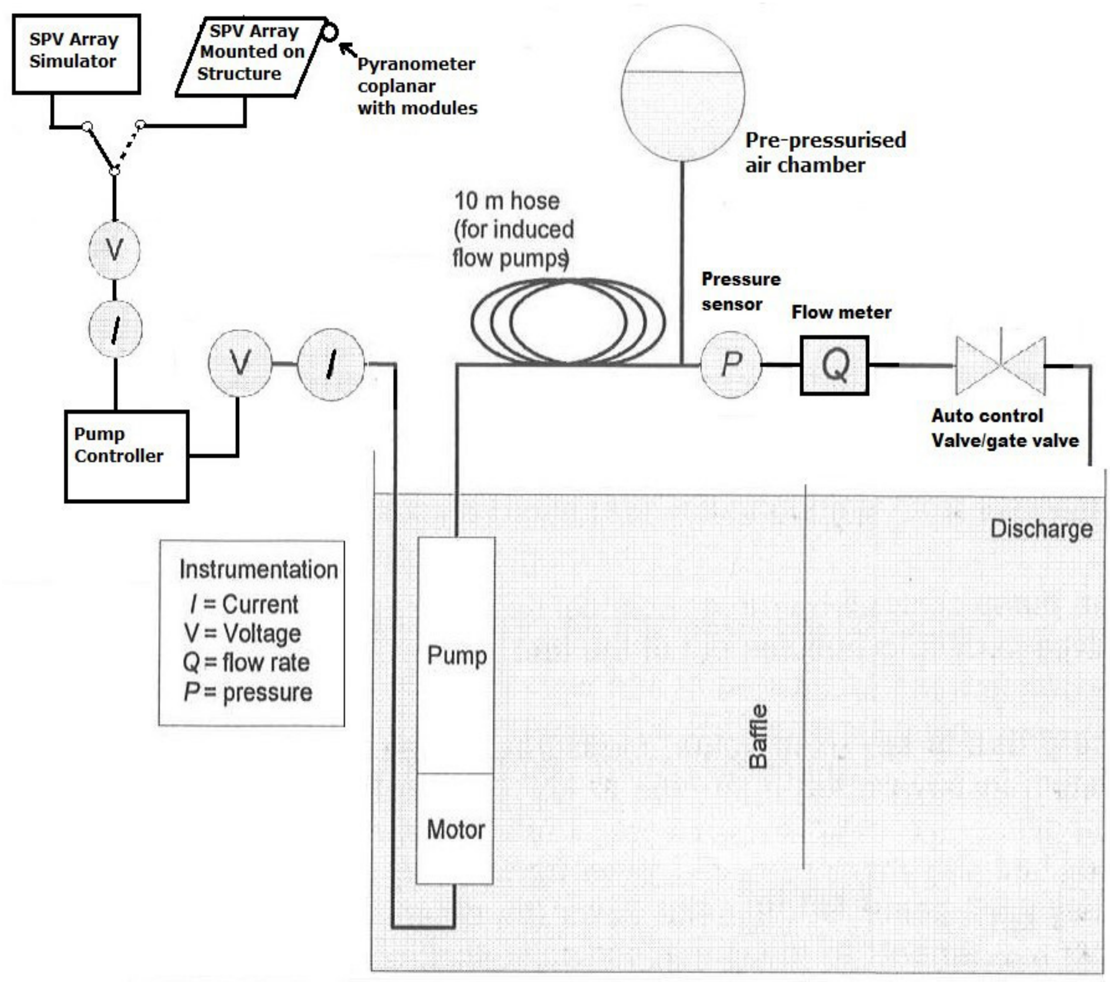

SPV Array Simulator
SPV Array Mounted on Structure
Pyranometer coplanar with modules
V
I
Pump Controller
V
I
10 m hose (for induced flow pumps)
Pre-pressurised air chamber
Pressure sensor
Flow meter
P
Q
Auto control Valve/gate valve
Discharge
Instrumentation
I = Current
V = Voltage
Q = flow rate
P = pressure
Pump
Motor
Baffle

FIG. 3 – BLOCK DIAGRAM OF TEST SETUP FOR SUBMERSIBLE PUMP-SET

a) In case of direct coupled pump-set, proper alignment of input pipe, output pipe and the sensors shall be ensured;

b) Air-tightness in suction line shall be ensured and the general layout of the system pipe work shall be designed to avoid airlocks;

c) The offset pipe of suction line shall either be horizontal or inclined upward towards the pump and shall never be inclined downward towards the pump to avoid air trapping;

d) For the delivery head, a pressure gauge/sensor shall be connected to the delivery line with tapping as shown in Figs. 1 or 2 or 3. The tapping shall be flush with the inside of the pipe and shall have its axis at right angles to the direction of flow. The pipe set up between the pump outlet and the pressure sensor shall be the same diameter as the manufacturer's outlet fitting. Sensor/gauge may be connected to the tapping point through a flexible hose;

e) Preferably, digital pressure sensor/gauges of suitable range need to be used for the measurement of head. Care shall be taken to eliminate any leaks in the connecting pipes and to avoid the trapping of air in the connecting pipe or hose;

f) It is assumed that over the normal operating range of the pump the pressure drop due to frictional losses between the pump outlet and the pressure sensor will be negligible and the kinetic energy component of the water at the pump outlet will be small compared to the increase in potential energy due to the increased pressure across the pump;

g) For instantaneous performance testing, pressure can be sustained by means of a simple gate valve in which a back pressure is sustained by restricting the flow. An automatic control valve(s) may be used to sustain a constant upstream pressure. Pressure may also be sustained by means of a pre-pressurized air chamber operating with a pressure maintaining valve at the outlet. A real water column may also be used;

h) A good quality digital flow meter with electrical output linearly proportional to flow rate shall be connected at the other end of the delivery pipe. The distance between the auto control valve and flow meter shall be more than 5*d* (*d* = pipe diameter) meters to ensure laminar flow of water; and

j) After flow meter the end of the discharge pipe shall be beneath the water surface to prevent splashing. This could cause a mixed water / air bubbles fluid entering the pump inlet and affecting its operation. If so then a vertical baffle or a similar arrangement shall be inserted in the tank between the pump intake and the return pipe such that water does not make any splash and avoid any bubbles when spread to the bottom of tank to reach the input pump. In this way any small bubbles will be excluded, as they will remain near the surface. Alternatively, a large pipe can be placed around the pump with its top breaking the surface and an arch cut in its base to allow water entry.

4.3 Priming Arrangement

A non-return valve/foot valve shall be used in suction line, further it may also require suction pipe need to be filled with water for priming purpose in case of surface pumps.

4.4 PV Module Array Structures

For testing the SPV pump using the actual solar array, outdoor PV array structures with different module mounting capacity (4, 6, 8, 10 etc.) shall be used. The modules are mounted on the structures with tracking facility to optimize irradiance, power output and accordingly, the total quantity of water pumped in a day.

4.5 Sun Simulator PV Module Tester

To estimate the wattage of the PV modules under STC, a high precession (at least class AAA as per IEC 60904-9) sun simulator module tester is required in the pump testing lab. Alternatively, all PV modules shall have STC testing certificate from an NABL accredited test laboratory and the date of testing shall not be later than a year. In the STC testing, if the module is found degraded, the degraded data shall be used.

4.6 Simulator (Electrical)Testing

Ideally, the SPV pump shall be tested as per the site conditions where it is designed to operate. The details of outdoor testing are discussed in the next sessions. However, for testing under simulated conditions, a programmable Solar PV (SPV) array simulator capable of simulating a given solar PV array configuration (that is. the number of modules, the type and the series/parallel combination), site radiation and temperature conditions shall be required for laboratory. Measurement equipment with acceptable accuracy and precision shall be used for detection and data logging of the parameters listed in Table 2.

Table 2 Core Parameters to be Measured and Recorded

(*Clause* 4.6)

Sl No. (1)	Parameter (2)	Symbol (3)	Unit (4)	Measurement Uncertainty (5)
i)	SPV Array voltage	V_a	V	≤ 1 percent
ii)	SPV Array current	I_a	A	≤ 1 percent
iii)	Pressure/head as measured	p	kg/cm^2	≤ 2 percent
iv)	Flow rate	Q	lps	≤ 2 percent
v)	Solar irradiance	E_e	w/m^2	≤ 2 percent

4.7 Test Setup

For the performance testing of SPV pumps a sump well with sensors for sensing, monitoring and recording of pump parameters will be required. The details of the resources required are given below:

a) Water tank / sump of required dimensions;

b) PV Modules, Controller, Motor-pump set, Cable as per required depth and Other Accessories (Test sample);

c) Pressure transducer with data logging system;

d) Flow Meter with data logging system;

e) Suction pipe(s) (if applicable);

f) Discharge pipe(s);

g) Pyranometers and Temperature sensors with data logging system;

h) Auto control valves;

j) SPV array Simulator(s) for simulation of module arrays for testing;

k) SPV array for realistic testing;

m) Structure for mounting modules for realistic condition testing; and

n) AAA class Sun simulator for testing of modules performance at STC.

(*See* Block diagram at fig. 3).

4.8 Constant Head Requirement

Dynamic head variation during test shall be within limit as specified in column 2 of table 3 and the allowable variation in arithmetic average (from start of flow point to end of flow point *see* fig. 5) of dynamic head shall be within value specified in col. 4 of Table 3. Any data with head variation during the test beyond the limit specified in col. 3 of Table 3 shall be treated as garbage data and shall not considered in calculations of daily water output.

Table 3 Allowable Variation in Arithmetic Average of Dynamic Head

(*Clause* 4.8)

Sl No.	Required Dynamic Head m	Allowable Variation in Dynamic Head During Test	Allowable Variation in Arithmetic Average of Dynamic Head
(1)	(2)	(3)	(4)
i)	10	± 15 percent = ± 1.5 m	± 0.5 m
ii)	20	± 10 percent = ± 2 m	± 0.5 m
iii)	30	± 10 percent = ± 3 m	± 0.7 m
iv)	50	± 8 percent = ± 4 m	± 0.8 m
v)	70	± 7 percent = ± 4.9 m	± 0.8 m
vi)	100	± 7 percent = ± 7 m	± 1 m

5 TEST PROCEDURE FOR PERFORMANCE EVALUATION OF SPV PUMPINGSYSTEM

There are three major profiles to be completed for comprehensive certification and qualification of a sample SPV water pump as per this standard. Two steps correspond to two simulation profiles, Hot and Cold. The third step corresponds to actual outdoor conditions testing using natural sun radiation. The SPV water pump sample shall attain or exceed the qualification bench marks set by BIS for the specified model and design, in all the three profiles. Before executing the three profiles testing, it is necessary to conduct the following protections test on the sample:

a) *Dry running* — System shall shut down within one minute/manufacturer specification in dry running condition (when water level goes below pump inlet);

b) *Open circuit* — System shall not operate if any phase becomes open-circuited, the controller shall be tripped within one minute/manufacturer specified time;

c) *Short circuit* — System shall not operate, if any two or all three phase short-circuited.;

d) *Reverse polarity* — System shall not malfunction if polarity of input power is reverse;

e) *Under voltage*— System shall not operate if terminal voltage goes below limit specified by manufacturer; and

f) *Surge protection* — Surge protection device (SPD) shall be installed on both the inputs and outputs side.

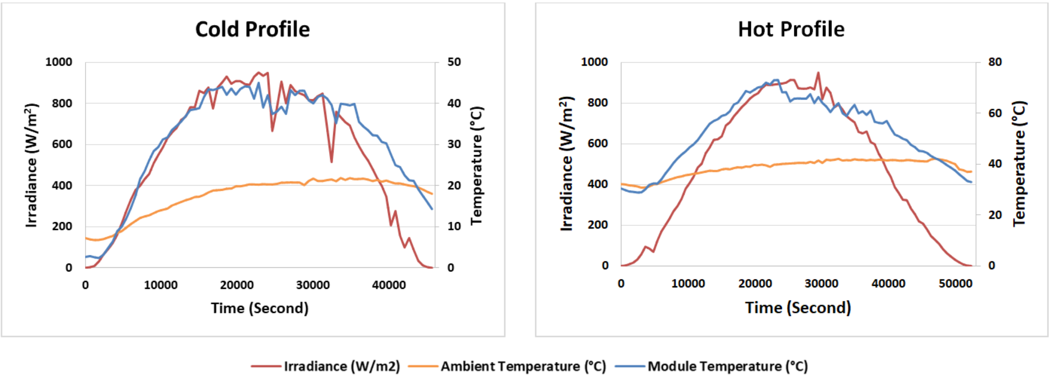
The performance testing of SPV pumping system for the three procedures are discussed in following sections:

5.1 Simulator Methods

Simulation methods are the easiest and fastest way of estimating SPV pump performance. However, in these methods actual PV array is not used, instead a PV array simulator is used. Here, a Programmable SPV array simulator capable of generating power output equal to actual SPV array under the given radiation and temperature conditions for given SPV array configuration (i.e. the number of modules, the type and the series / parallel combination) shall be used. Although any radiation and temperature and be created, for the purpose of testing, two conditions one Hot summer day conditions (hot profile) and the other Winter day conditions (cold profile) shall be used.

5.2 Hot and Cold Profiles

The typical Hot and Cold day profiles are shown in Fig. 4. These profiles of full day solar irradiance and temperature shall be loaded in PV array simulator, sequentially one after the other. The simulator output is connected to the motor and pump through the pump controller and the profiles are run on real time basis. The performance parameters as given in Table 2 are collected every minute for the entire duration of run time (per day). The total water output and output in liters/watt STC/day can be estimated at desired constant head / dynamic head for complete duration of profiles. Temperature coefficient of power shall be derived from the IEC 61215/IS 14286 standard test report for the module supplied with the pump of the same model.



NOTE —Per second data for hot and cold profile attached at Annex B

FIG. 4 – TYPICAL SOLAR RADIATION HOT AND COLD PROFILE

5.3 Outdoor Condition Using Sun Radiation

To operate the motor-pump set using actual PV array, an array as per the Motor-pump set HP capacity to be designed. The STC wattage of all the PV modules is measured first, as per IEC 60904-1/ IS 12762-1 or **11.6** of IEC 61215/ **10.6** of IS 14286. The modules will then be installed on the structures, both in series and parallel combinations, as required, are connected and designed PV module array is created. The array output is connected to Motor and Pump through pump controller

Per day water output test to be performed at desired constant dynamic head for complete day from dawn to dusk (sunrise to sunset). Irradiance shall be measured at coplanar to modules. Tracking may be done manually or automatically. Total flow shall be corrected at reference Average Daily Solar Radiation of 7.15 kWh/ m2 on the surface of SPV array (i.e. coplanar with the SPV Modules).

Results of the SPV pumping system obtained under outdoor condition shall meet the performance requirements of the system.

Recoding, measurement and logging of flow for the period of hot profile, cold profile and realistic condition need to be done.

NOTES

1 Handle PV modules carefully during installation.

2 PV modules to be free from dirt (sand, bird droppings etc.) during test.

3 Install PV modules in shadow free access controlled area.

4 Tracking shall be minimum three time in a day for maximum performance

5 Pyranometer shall be mounted coplanar with SPV modules.

5.4 Remote Monitoring System Verification

Provision for remote monitoring of the installed pumps shall be made in the controllers through an integral arrangement and it shall be capable of providing live status/parameters through online portal.

6 MEASUREMENTS ANDAPPARATUS

6.1 Solar Radiation Measurement

Solar radiation at coplanar with module surface shall be measured using pyranometer. Response time of pyranometer shall not be more than 15 s. Interval between two readings shall not be more than one minute for the calculation of average daily solar radiation.

6.2 Measurement of Head

6.2.1 *Delivery Head*

Digital pressure gauge/sensor shall be used, also a data logging system shall be used for calculation of average head through day. Interval between two readings shall not be more than one minutes for the calculation of average head. Accuracy for pressure sensor shall be within ± 0.5percent.

6.2.2 *Suction Lift*

Suction lift shall be kept constant by mean of vertical distance from sump water level to centre of pump impeller. Correction in suction lift shall be applied as per atmospheric pressure at the testing place and water temperature.

Distance measuring scale or laser-based sensors may also be used for suction lift measurement.

6.3 Measurement of Rate of Flow

A magnetic flow meter of minimum 0.5 percent accuracy class shall be used for flow measurement; data logging system shall be used for calculation of cumulative water volume throughout the day. The maximum flow rate of flow meters shall be at least 1.5 times the maximum flow rate of pumps. Instruments can be selected as per 3.2 of IS 11346. Interval between two readings shall not be more than one minute for the calculation of cumulative flow. Accuracy for flow meters shall be within ± 0.5percent.

7 CALIBRATION OFAPPARATUS

All measuring instruments are to be calibrated periodically as per requirement.

8 STEP-WISE TEST PROCEDURE

8.1 Per Day Water Flow Test of Submersible Pumps

a) Install the pump-set as per Fig.1;

b) Connect pump-set with controller as per manufacturer instruction;

c) Use Solar PV Array Simulator Or actual output from SPV array, for testing of pump-set at given profile;

d) Connect controller with PV array Simulator or with actual SPV array output as per requirement of profile;

e) Input STC performance data of each module in the array, into simulator and invoke the desired profile and run the same;

f) For realistic condition test, make array by mounting all SPV modules on structure(s) by connecting modules in series or parallel as per requirement;

g) Start controller after connecting it with array or array simulator;

h) Use head control valve or pre-pressurize tank to keep constant desired dynamic head; and

j) Record parameters as given in table 2 recording interval shall be ≤ 1 minute.

8.2 Per Day Water Flow Test of Surface Pumps

a) Install pumps as per Fig. 2;

b) Maintain height to get desirable static suction lift as per requirement;

c) Install of foot valve or non-return valve as per manufacturer instructions; and

d) Follow steps **8.1 (b) to 8.1 (5)**.

9 OBSERVATIONS

The following observations of complete day profile shall be recorded in a test record sheet. These observations shall be used to derive pump characteristics:

a) Instantaneous Solar irradiation (W/m^2), pyranometer reading;

b) Delivery gauge/sensor readings;

c) Distance between water level to impeller eye, (if applicable);

d) Gauge distance correction factor, Z;

e) Calculate cumulative daily solar radiation coplanar with solar modules(kWh/m2);

f) Calculate total water discharge in a day at desirable constant head (litre per day); and

g) Water output per day per watts peak (litre/Wp).

10 COMPUTATION OF TESTREADINGS

10.1 Computation of Total Head for Surface (Monoset) Pumps

$$\text{Total head } (h) = Hssl + H_d + Z + [\,(V_d^2 - V_s^2) / 2g\,]$$

H_{SSL} = Total Static suction Lift in meters of water column (measured by calibrated measuring tape or any distance measuring sensors)

H_d = Delivery gauge/sensor reading in meters of water column

Z = Gauge distance correction factor for delivery gauge centre and inlet pipe centre in meters (*see* Fig 3). If the delivery gauge centre is below the inlet pipe centre, Z is subtracted from the delivery gauge reading and if the delivery gauge centre is above inlet pipe centre, Z is added to the delivery gauge reading; the gauge distance correction factor shall never be applied to the suction Vacuum gauge or mercury manometer reading irrespective of their positions:

V_d = Velocity at delivery gauge/sensor connection, m/s;

V_s = Velocity in suction pipe, m/s; and

g = Acceleration due to gravity, in m/s^2.

The Total Static Suction Lift in surface pump (H_{SSL})

H_{SSL} = Height in meter from water level to impeller + Altitude correction in meter + water temperature correction in meter.

10.1.1 *Correction for Altitude*

Barometric pressure shall be recorded at test place. The difference between atmospheric pressure at the test place and 10.33 mWC (that is atmospheric pressure at MSL) shall be deducted from Static suction lift.

10.1.2 *Correction for Water Temperature*

Static suction lift specified in below table shall be increased or reduced as given below when water temperature is below or above 33°C.

Table 4 Correction for Water Temperature

Hourly Average of Water Temperature	Vapour Pressure	Correction in Static Suction lift A above and below 33°C water temperature
°C	mWC	m WC
10	013	+ 0.39
15	0.18	+ 0.34
20	0.24	+ 0.28
25	0.33	+ 0.19
30	0.43	+ 0.09
33	0.52	0.00
35	0.58	- 0.06
40	0.76	- 0.24
45	1.00	- 0.48
50	1.28	- 0.76

Suction lift shall be adjusted minimum 3 time in a day as per average water temperature and barometric pressure, by adjusting water level of tank.

Following formula can also be used on behalf of Table 4, $y = -0.000\,7\,x^2 + 0.013\,0\,x + 0.307\,9$

where

y = correction in Static suction lift, and

x = Average of water temperature.

10.2 Computation of Total Head for Submersible Pump-sets

$$\text{Total head, } h = H_d + z + [\,(V_d^2) / 2g)\,]$$

where

H_d = delivery gauge/sensor reading in meters of water column;

Z = gauge distance correction factor for delivery gauge. Distance between gauge/sensor center to tank water level (*see* Fig. 1).

V_d = velocity at delivery gauge/sensor connection in m/s; g = Acceleration due to gravity, in m/s^2.

10.3 Total Water Per-Day

Total per day water output shall be calculated by Integration (Sum) of flow rate with respect to time. Integration shall start from the time when pumpset achieve desired constant head in morning time (start point *see* Fig. 5) and end at the time when pump set unable to achieve desired constant head in evening time (End point see Fig. 5).

In case if average daily solar radiation found less than requirement then test shall be performed on next sunny day.

10.4 Water Output Per Day Per Watt Peak

Water output per day per watts peak (litre/Wp) = Water output (Liters) per day at specified head / Array STC power in watts-peak

10.5 Cumulative Daily Solar Radiation

Cumulative Solar Radiation (kWh/m^2) in a day = Average of instantaneous irradiance reading from Dawn to Dusk (kW/m^2) period of time in hours.

This can be obtained through time weight summation of pyranometer readings.

Dawn = Time of sunrise when irradiance become positive from zero value.

Dusk = Time of sunset when irradiance become zero from positive value.

10.6 Mismatch in Maximum Power at STC Among Modules of Array

The mismatch shall be calculated as under:

$$\left[\frac{P_{\max} - P_{\min}}{P_{\max} - P_{\min}}\right] \times 100$$

Percent Power mis-match in array =

$P_{\max}$ = maximum power among modules in array, and

$P_{\min}$ = minimum power among modules in array.

10.7 Efficiency of Array

Efficiency of array = Power output from array / (total area of modules, in m^2 Sun radiation in watts/ m^2)

10.8 Fill Factor of Array

Fill factor of array = This has to be measured using a PV array tester. This depends on the overall series resistances and shunt resistances of modules in the array.

10.9 Output Voltage of Array

Output voltage of array = Sum of voltages of modules in series. In parallel connected module strings, the lowest voltage generating strings will set the voltage.

10.10 Output Current of Array

Output Current of an Array = Sum of currents of the parallel strings in the array. The output current of a string is controlled by the lowest current generating module.

10.11 Output Power of Array

Output power of array = Sum of power of all modules-mismatch loss This can be measured by PV array tester.

11 EXAMPLES

Total per day flow

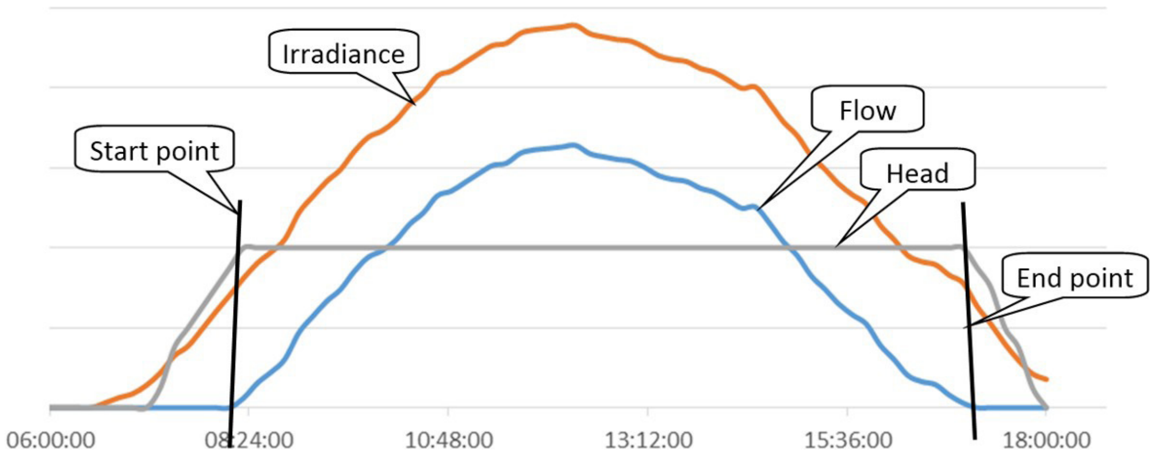


FIG. 5 TYPICAL GRAPH FOR UNDERSTANDING CALCULATION

If pump achieved constant head at 8:15:30 AM (Start point in Fig. 5) and in evening pump unable to keep constant desired head at 17:45:30 PM End point in Fig. 5).

Flow rate in lps is recorded from 08:15:30 AM to 17:45:30 PM (start point to end point) If the average lps calculated is 3.55 lps then total flow will be

Total duration of flow = End time – Start time

= 17:45:30 – 8:15:30

= 9 h: 30 m : 0 s Total duration from start to end seconds:

= (9 × 3 600) + (30 × 60) + (0 × 1) = 34 200 s.

Total per day flow in litre = Average flow in lps total seconds from dawn to dusk

= 3.55 34 200 = 121 410 litters

For realistic test, correct total flow at reference Average Daily Solar Radiation as specified in BIS specifications.

12 USE OF OTHER BRAND OF SOLARMODULES

In case a test lab has tested and issued approval certificate for a particular model of SPV pumping system using particular brand and a particular W_p of SPV Modules, SPV Modules of other brand may also be used for the purpose for the same model of SPV pumping system without going for retesting of SPV pumping system with other brand (or the higher W_p of same brand) of SPV Modules provided the test lab certifies that the SPV Module of other brand (or originally tested brand) is at least of same wattage capacity and its parameters and characteristics are not inferior to the brand of SPV Module with which the model of SPV pumping system was tested and certified by the testing lab.

Following criterion shall be followed:

a) Solar array maximum voltage V_{mpp} with new brand module shall be within ± 2 percent of earlier module.

b) Modules efficiency and fill factor shall qualify minimum requirement of BIS specifications; and

c) Array and module Mismatch shall meet the BIS specifications.

ANNEXA

(*Clause* 2)

LIST OF REFERRED STANDARDS

IS No.	*Title*
3043: 1987	Code of practice for earthing
5120 : 1977	Technical requirements for rotodynamic special purpose pumps (*first revision*)
6603 : 2001	Stainless steel bars and flats
6911 : 2017	Stainless steel plate, sheet and strip stainless steel plate, sheet and strip
7538 : 1996	Three-phase squirrel cage induction motors for centrifugal pumps for agricultural applications
8034 : 2018	Submersible pump sets — Specification (*second revision*)
9079 : 2018	Electric monoset pumps for clear, cold water for agricultural and water supply purposes — Specification (*second revision*)
9283 : 2013	Motors for submersible pump sets
11346 : 2002	Code of acceptance tests for agricultural and water supply pumps (*first revision*)
11346 : 2003	Tests for agricultural and water supply pumps — Code of acceptance
14220 : 2018	Openwell submersible pump sets — Specification
14286 : 2010	Crystalline silicon terrestrial photovoltaic (PV) modules — Design qualification and type approval
14582 :1998	Single-phase small AC electric motors for centrifugal pumps for agricultural applications
17018-1 : 2018	Solar photovoltaic water pumping system Part 1 Centrifugal pumps — Specification
ISO 9905 : 1994	Technical specifications for centrifugal pumps — Class I
IEC 60068-2-6 : 2007	Environmental testing — Part 2-6 Tests — Test Fc: Vibration (sinusoidal)
IEC 60068-2-30 : 2005	Environmental testing — Part 2-30 Tests — Test Db: Damp heat, cyclic (12+ 12h cycle)
IEC 60146-1-1 : 2009	Semiconductor converters — General requirements and line commutated converters Part 1-1 Specification of basic requirements
IEC 60364-4-41 : 2005	Low-voltage electrical installations — Part 4-41: Protection for safety - Protection against electric shock
IEC 60364-7-712 : 2017	Low voltage electrical installations — Part 7-712: Requirements for special installations or locations — Solar photovoltaic (PV) power supply systems
IEC 60529 : 1989	Degrees of protection provided by enclosures (IP Code)
IEC 60947-1 : 2007	Low-voltage switchgear and control gear — Part 1: General rules
IEC 61000-6-2 : 2016	Electromagnetic compatibility (EMC) — Part 6-2: Generic standards - Immunity standard for industrial environments
IEC 61000-6-3 : 2006	Electromagnetic compatibility (EMC) — Part 6-3: Generic standards - Emission standard for residential, commercial and light-industrial environments
IS/IEC 61683 : 1999	Photovoltaic Systems — Power Conditioners — Procedure for Measuring Efficiency
IS/IEC 61730-1 : 2004	Photovoltaic (Photo Voltaic (PV)) Module Safety Qualification Part 1 Requirements for Construction

IS No.	*Title*
IS/IEC 61730-2 : 2004	Photovoltaic (Photo Voltaic (PV)) Module Safety Qualification Part 2 Requirements for Testing
IEC 61800-3 : 2017	Adjustable speed electrical power drive systems — Part 3: EMC requirements and specific test methods
IEC 62109-1 : 2010	Safety of power converters for use in photovoltaic power systems — Part 1: General requirements
IEC 62305-3 : 2010	Protection against lightning — Part 3: Physical damage to structures and life hazard
IEC 62458 : 2010	Sound system equipment — Electro-acoustical transducers — Measurement of large signal parameters

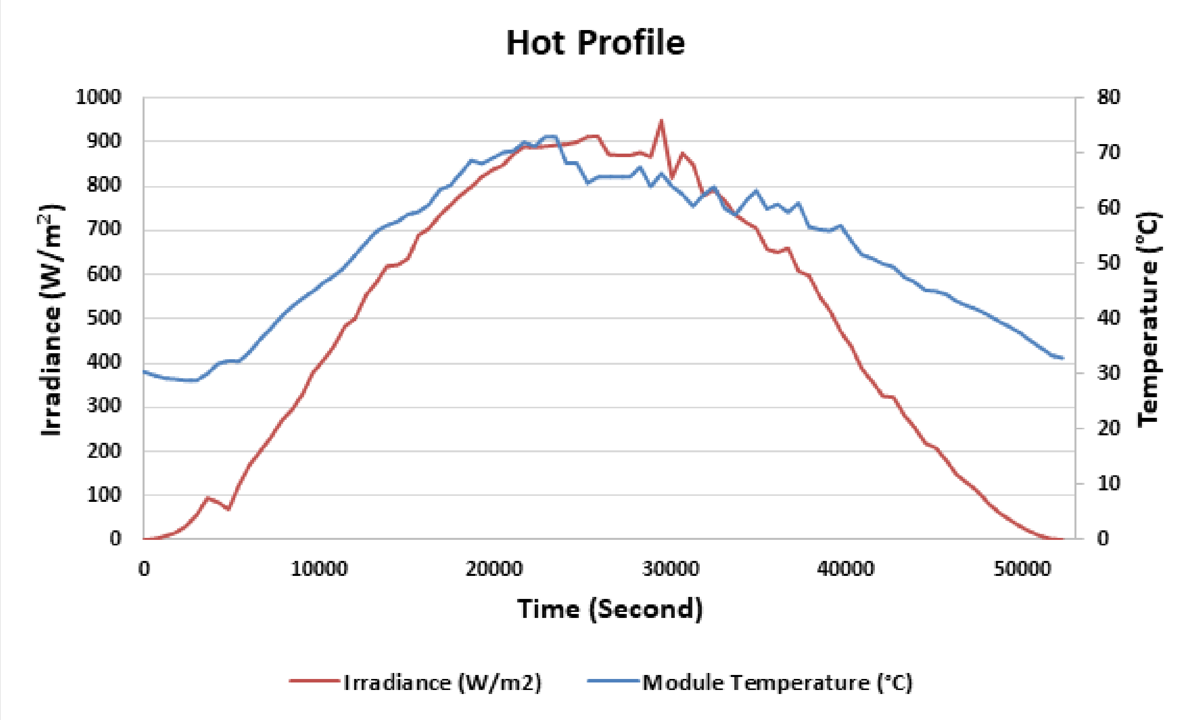
ANNEX B

(*Clause* 5.2)

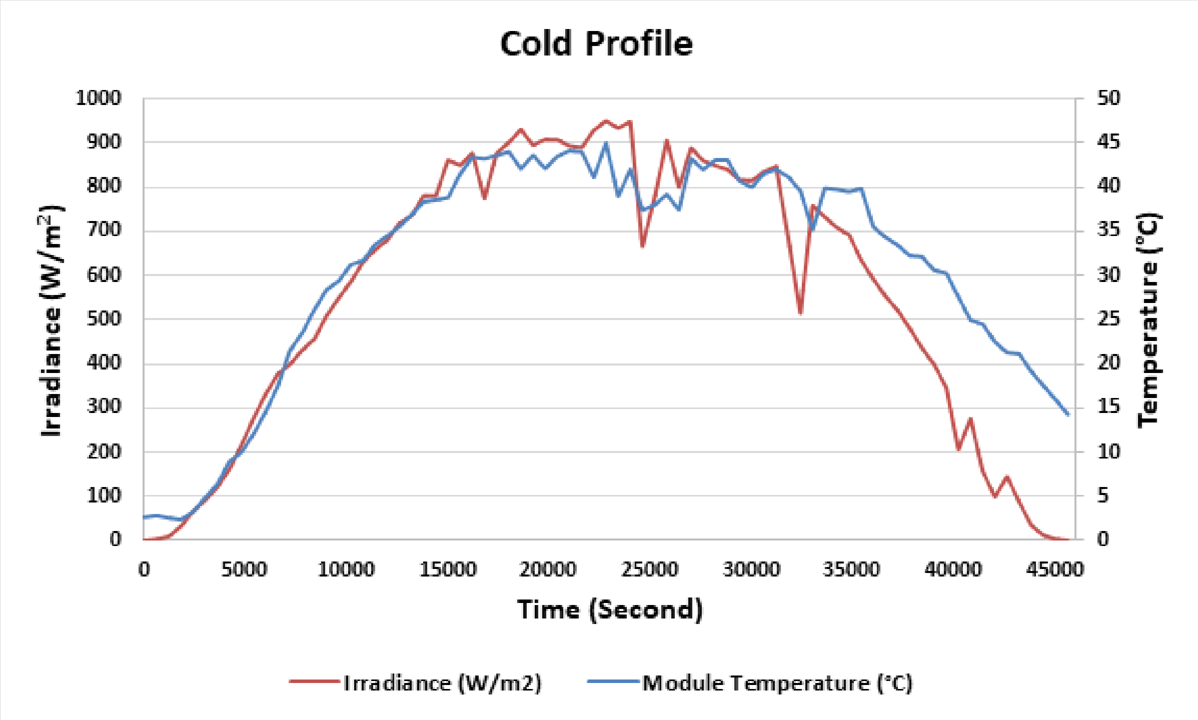
PER SECOND DATA FOR HOT AND COLD PROFILE

(*Individual data for irradiance values are available on MNRE website*)

A) PER SECOND DATA FOR HOT PROFILE



A) PER SECOND DATA FOR COLD PROFILE



ANNEX C

(*Foreword*)

COMMITTEE COMPOSITION

Pumps Sectional Committee, MED 20

Organization	*Representative(s)*
Fertilizers and Chemicals Travancore (FACT), New Delhi	Shri A. K. Nijhawan (***Chairman***)
AQUASUB Engineering, Coimbatore	Dr C. Muthu Shri C. Murugesan (*Alternate*)
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Gail India Ltd, New Delhi	Shri Satish Geda
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International Copper Association India, Mumbai	Shri Abhishek Dhupar Shri DebdasGoswami (*Alternate*)
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Kirloskar Ebara Pumps Ltd, Pune	Shri A. S. Joshi Shri V. K. Shrivastava (*Alternate*)
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Mecon Limited, Ranchi	Shri P. S. Rao Shri A. Gangal (*Alternate*)
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The Southern India Engg Manufacturers Association, Coimbatore	Shri K.V. Kartik Shri D. Jayaprakash (*Alternate*)
Wilo Mather and Platt Pumps Ltd; Pune	Shri Manoj Bafna
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Vyoda Private Limited, Mysuru	Shri Padmakar Pratapure Shri Avinash Kumar (*Alternate*)
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